# *Update on the*

# Hurricane Nest Project


*32nd Conference on Hurricanes and Tropical Meteorology*

**April 20, 2016- San Juan, PR**

**Steven Diaz**

***CIMAS/U. Miami***

***NOAA/AOML/HRD***

***Numerical Modeling Group***

# High Impact Weather Prediction Project

*Funded by the Disaster Relief Appropriations Act of 2013*

**Project Manager**
T. Schneider, ESRL

**3.1 Hydrostatic Global Models**
POC: S. Benjamin, ESRL

**3.2 Non-Hydrostatic Gbl Models**
POC: J. Whitaker, ESRL

**3.3 Moving Hurricane Nests**
POC: S. G. Gopalakrishnan, AOML
& V. Tallapragada, NCEP

**3.4 NMME Expansion**
POC: J. Huang, NCEP

**3.5 Test Program**
POC: B. Strong, ESRL

# The Team

Personnel from:

| AOML Team | EMC Team |
|---|---|
| T. Quirino (Nesting) | T. Black (Nesting) |
| S. Diaz (Initialization) | M. Pyle (NPS) |
| X. Zhang (HWRF transitions) | Q. Liu (Initialization) |
| J. Delgado (Software support) | W. Wang (Physics) |
| J. Prusa (Idealized framework) | S. Trahan (Vortex tracker) |
| S.G.Gopalakrishnan (Analysis) | L. Zhu (Idealized framework) |

**In collaboration with:**

Mesoscale Modeling Group, EMC/NCEP, College Park, MD

**Acknowledgements:**

T. Schneider, R. Atlas, F. Marks, G. DiMego and F. Toepfer

# Outputs & Deliverables

*"The primary goal of this project is* the development of a global, non-hydrostatic, medium-range prediction system capable of explicitly resolving cloud processes…*"*

**--HIWPP Project Plan Oct. 2013**

- Create the next-generation, non-hydrostatic modeling system capable of better capture of multi-scale land-storm interactions (*emphasis on rainfall and size prediction*)
- Provide proof-of-concept of a global model with multiple moveable nests (*i.e., nests on all tropical cyclone systems worldwide*)
- Make available to other collaborators the options being developed in this effort to test the nesting system with IC's and BC's from different models (*within the NEMS framework*)

**NEMS compatible solvers include: GFS, GEFS, FIM, NMMB**

## NMMB

*(**N**onhydrostatic **M**ultiscale **M**odel on **B**-grid)*

- Global Configuration
  - Low resolution
  - No nests
- Regional Configuration
  - Single nest
  - No tracking
- Used in North American Mesoscale ('NAM') Model
- Compatible with NEMS

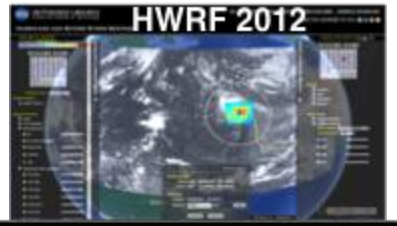
## HWRF

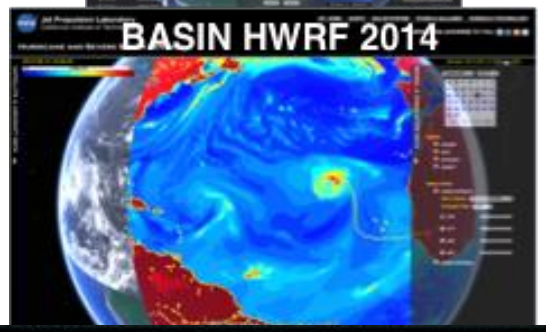
*(NMM on rotated E-grid)*

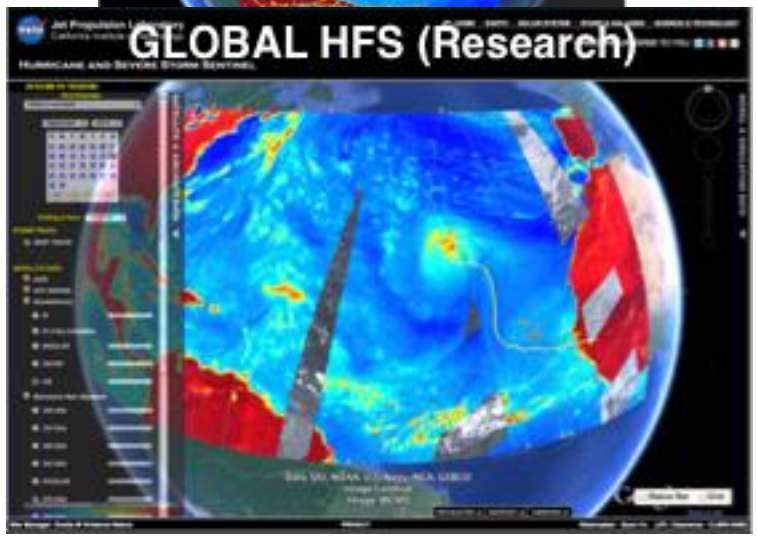
- Hurricane-specific components
- Operational Configuration
  - Proven capability
  - Single-storm only
- Basin-scale Configuration
  - Larger outer domain
  - Multi-storm capability
- Automated storm tracking
- Incompatible with NEMS

# The Plan

**Project Statement:** *"…All hurricane-specific components from HWRF will be transitioned to the NEMS framework…"*




- Make all hurricane-specific components compatible with NMMB (*nesting, physics, vortex initialization*)
- Mimic 2013 Basin-scale HWRF (**HFIP-funded product of HRD*)
- Demonstrate the feasibility of high resolution, multi-nested models on regional and global scales (focus on land-falling TCs)

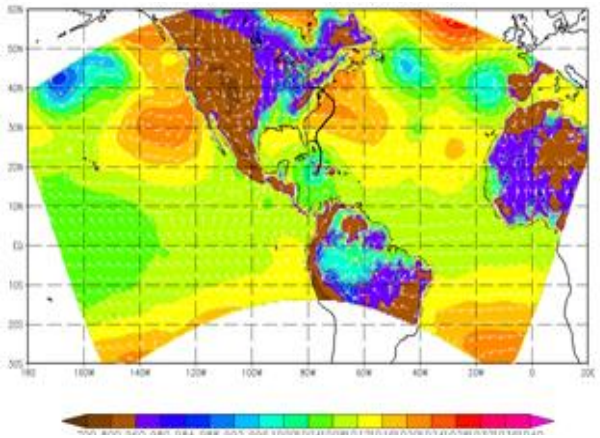
# Milestones

| Milestone | Completed |
|---|---|
| Configuration & Testing | Dec 2014 |
| HWRF Physics Transitions | Sept 2014 |
| Idealized Framework | April 2015 |
| HWRF Vortex Tracker | Jun 2015 |
| HWRF vortex initialization and cycling | Dec 2015 |
| Semi-Real Time testing | On-going |
| Multi-Season Testing, Verification, Rainfall Evaluation | Postponed due to lack of HPC |

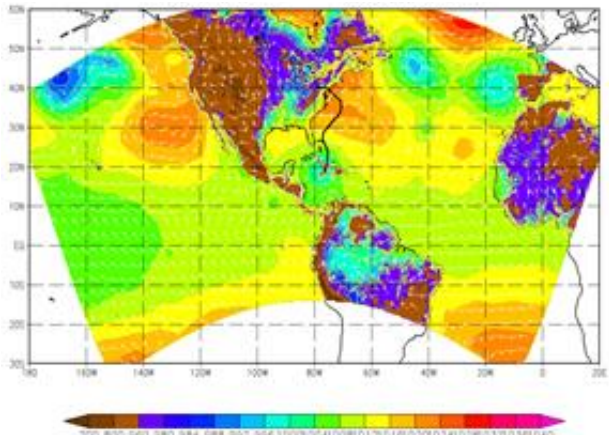
# Configuration and Testing (May 2014)

Seven day forecasts on 576 processors

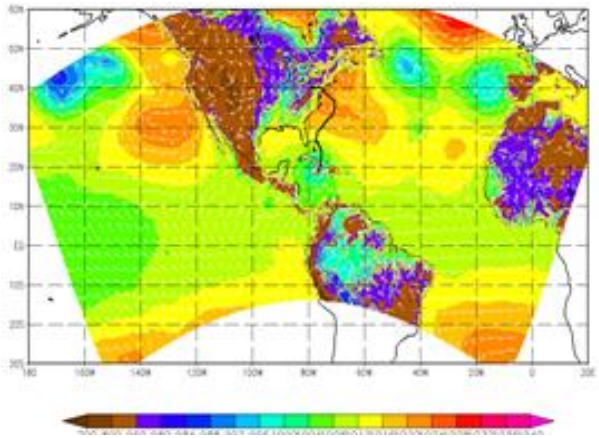
**Project Statement**: "…this project will leverage on NOAA's success with HWRF towards creating the next-generation HWRF within NEMS framework."



***54 km***: 359 x 157 grid w/61 levels
Runtime: **4 minutes**



***27 km:*** 716 x 313 grid w/61 levels
Runtime: **13 minutes**



***9 km:*** 1988 x 868 grid w/61 levels
Runtime**: 2 hours 10 min**

- Uniform ***3 km*** basin-scale run in progress – requires more dedicated nodes

# Definition of HWRF Physics

**HWRF Physics:** suite of subroutine options tailored for *tropical cyclones*

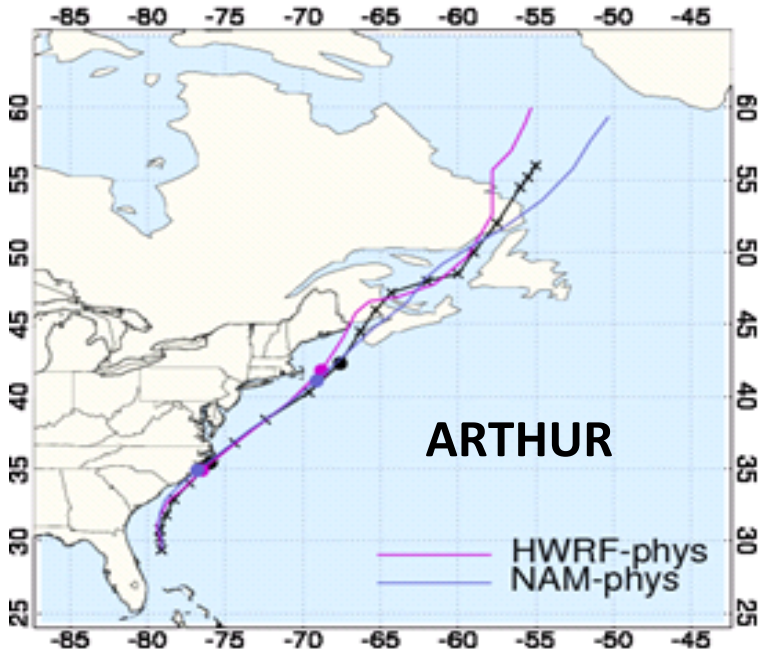
**NAM Physics:** suite of subroutine options tailored for *mesoscale phenomena*

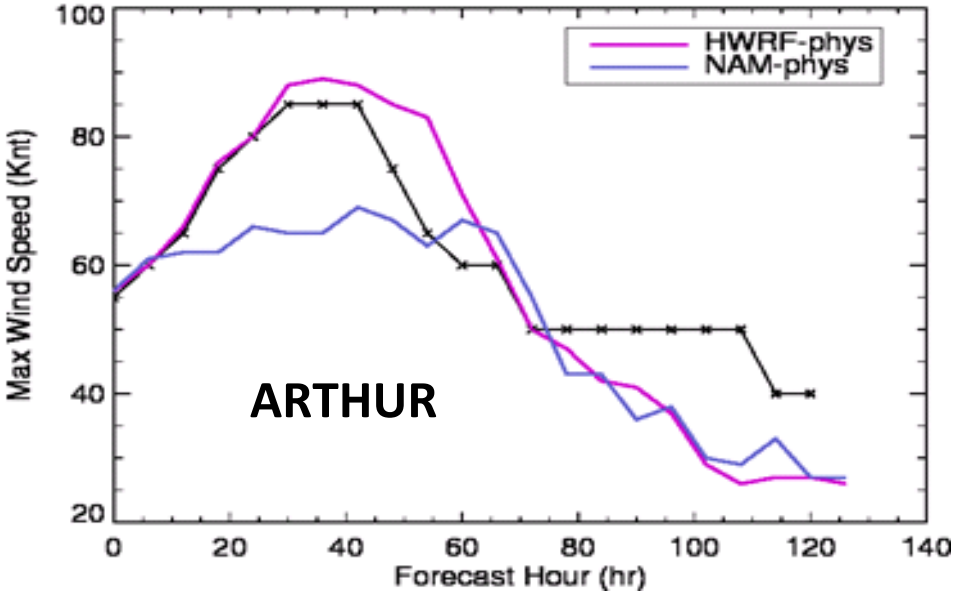
| Model/Scheme | "HWRF Physics" | "NAM Physics" |
|---|---|---|
| Radiation (LW): | RRTM | GFDL |
| Radiation (SW): | RRTM | GFDL |
| Convection: | SASHUR | BMJ |
| Microphysics: | FER_HIRES | FER |
| Turbulence: | GFSHUR | MYJ |
| Surface Layer: | GFDL | MYJ |
| Land Surface: | GFDLSLAB | NOAH |

# Impact of HWRF Physics

## 'HWRF Physics' vs 'NAM physics'

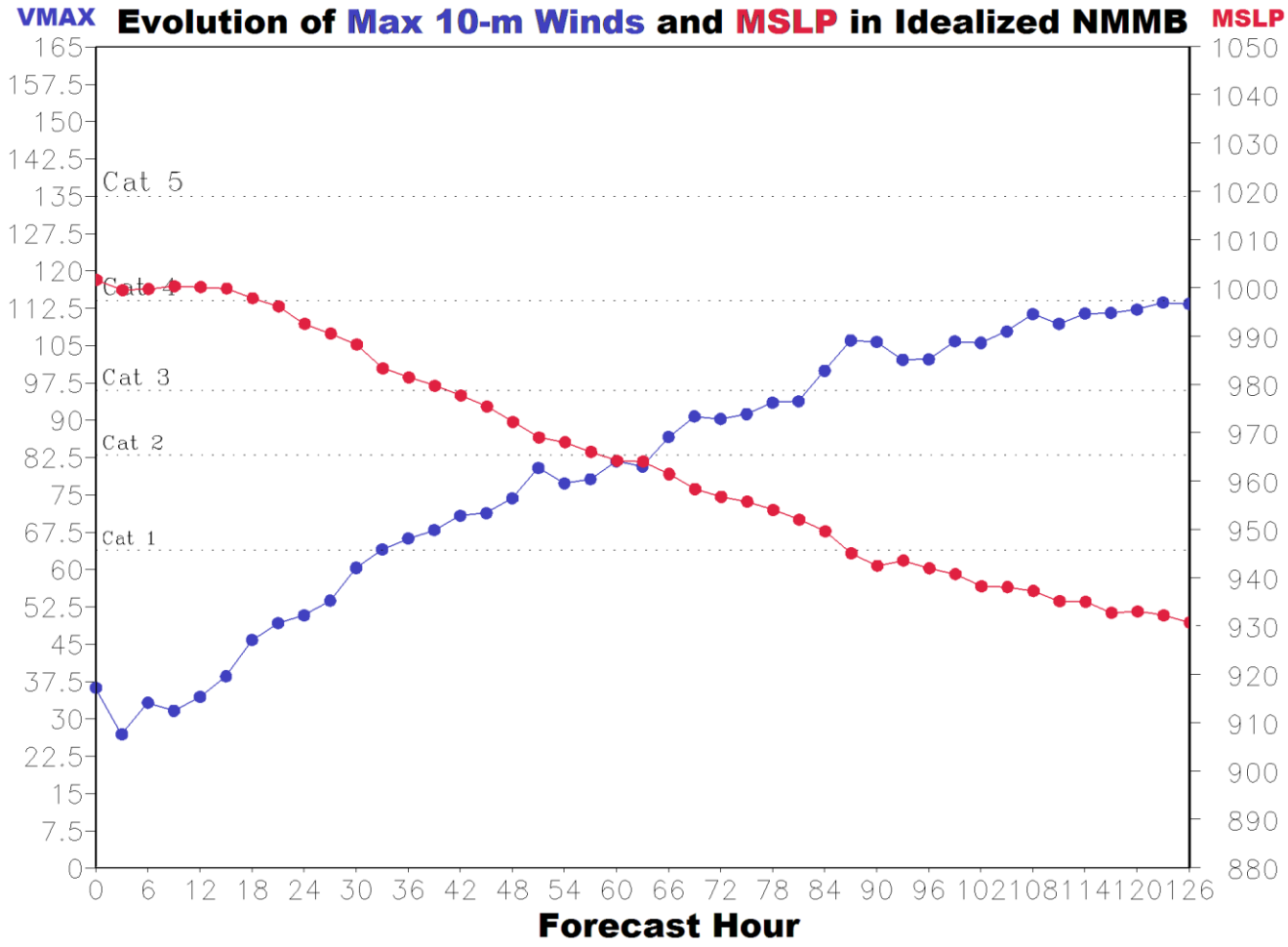
- In one case study, NMMB with 'HWRF physics' showed characteristics closer to the observations when compared to NMMB with 'NAM physics'.
- The 'NAM physics' produced a weaker hurricane compared to 'HWRF physics'.

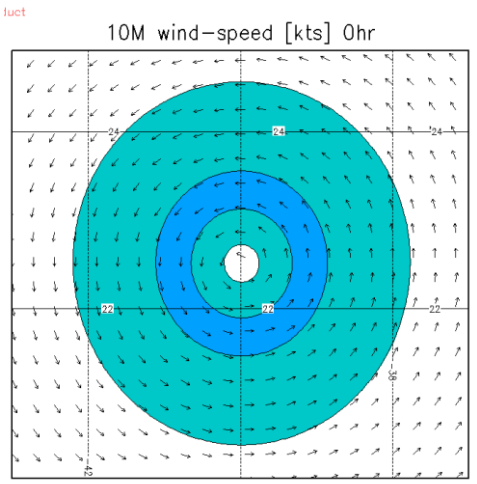


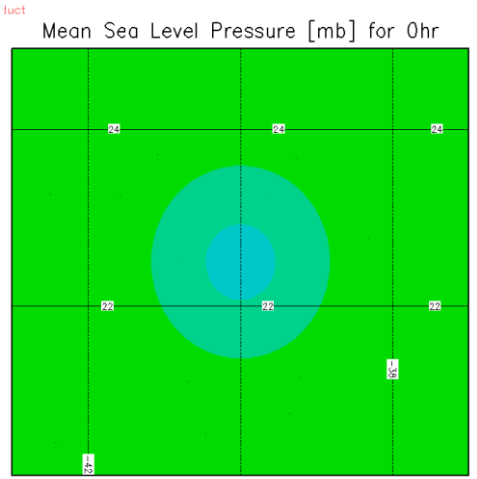



# Idealized Tropical Cyclone (ITC)

**Project Statement**: Develop Idealized capability for hurricane simulations in NMMB.



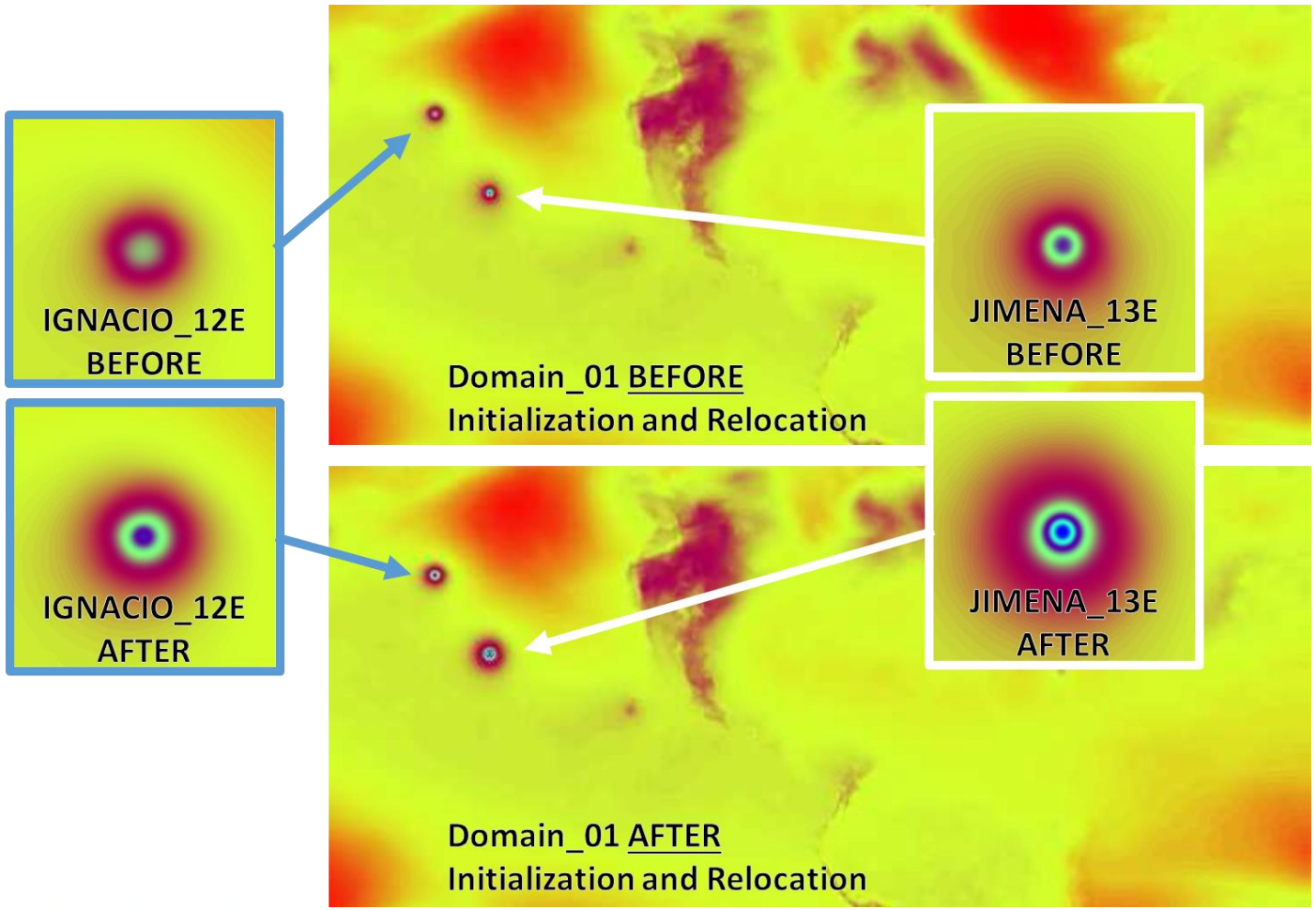




Initial date: 2010082618

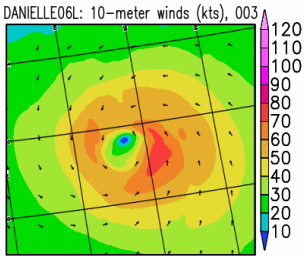
# Vortex Cycling for Multiple Storms

**Vortex-cycling:**

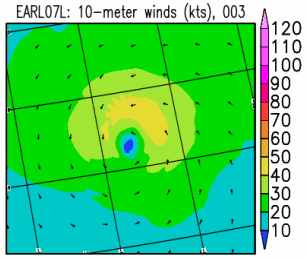
*The augmentation of the 0-hr GFS vortex, based on the previous 6-hr NMMB forecast.*



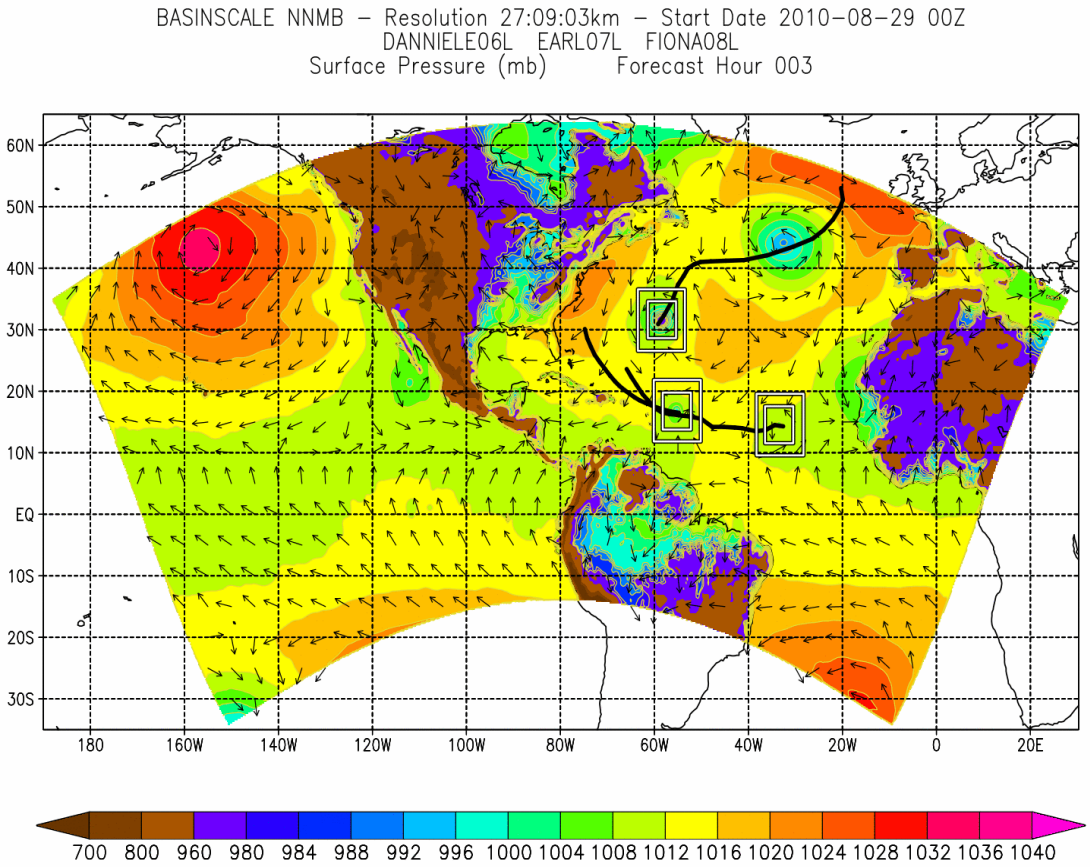
# The HNMMB System (Oct 2015)

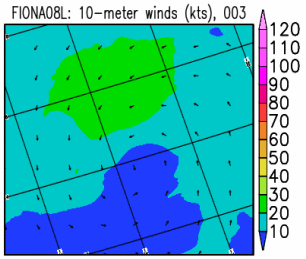



Danielle_06L




Earl_07L



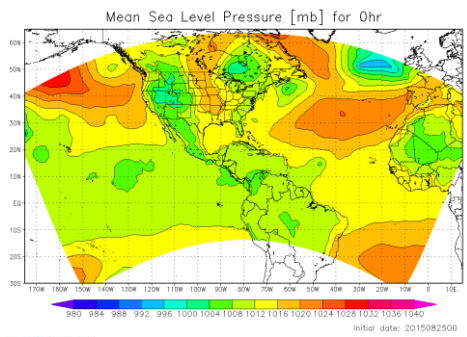



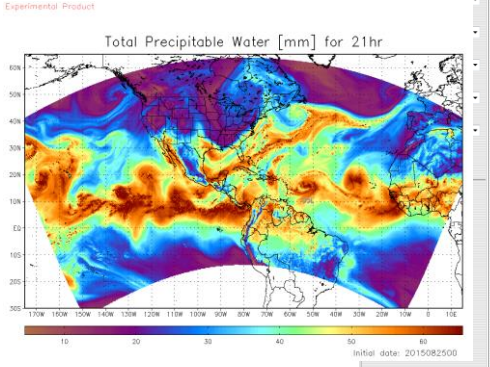

Fiona_08L

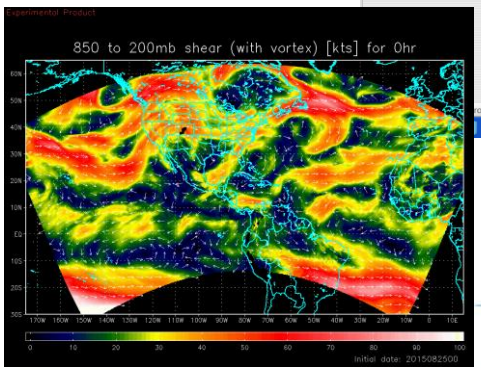
- NEMS framework
- NMMB dynamic core
- HWRF physics
- HWRF tracking
- HWRF cycling
- 18:6:2 km resolution
- Fully automated
- Version controlled
- Adv. diagnostics

# Experimental Web-Site/Products

http://storm.aoml.noaa.gov/hnmmb



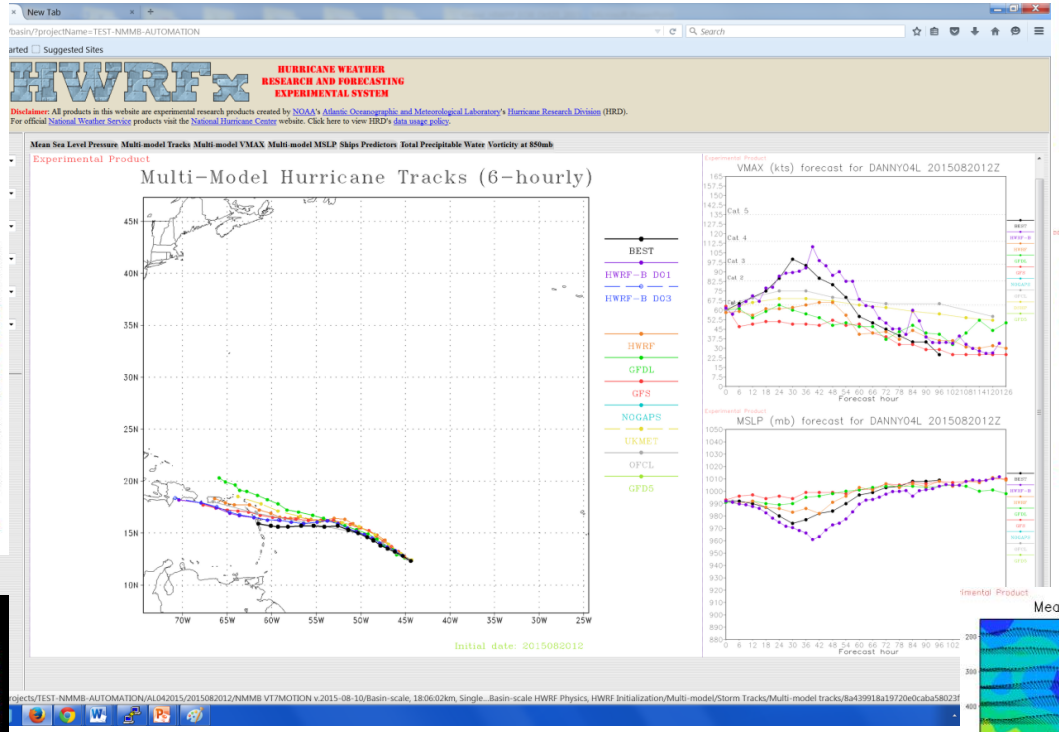



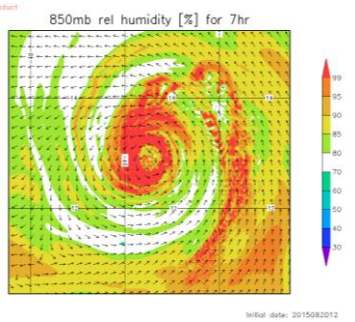



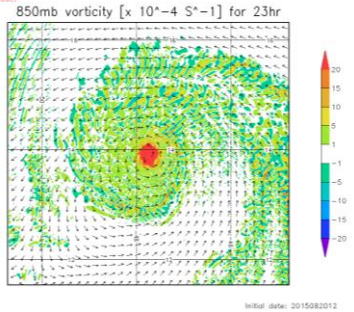

***HNMMB Products:*** *About 5000 graphics are produced per run!*

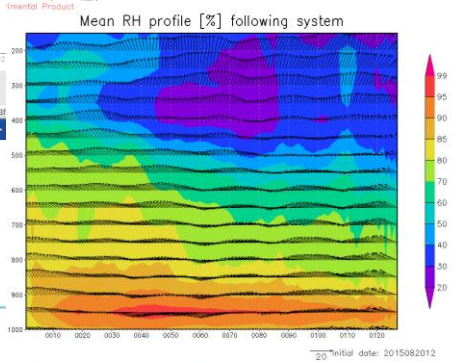
***Large scale (18 km):*** *Track, Int., Shear, Steering, Predictors, TPW, MSLP, Winds, etc.*

***Vortex Scale (2 km):*** *Warm core, Hovemoller, Vorticity, Winds, RH, etc.*



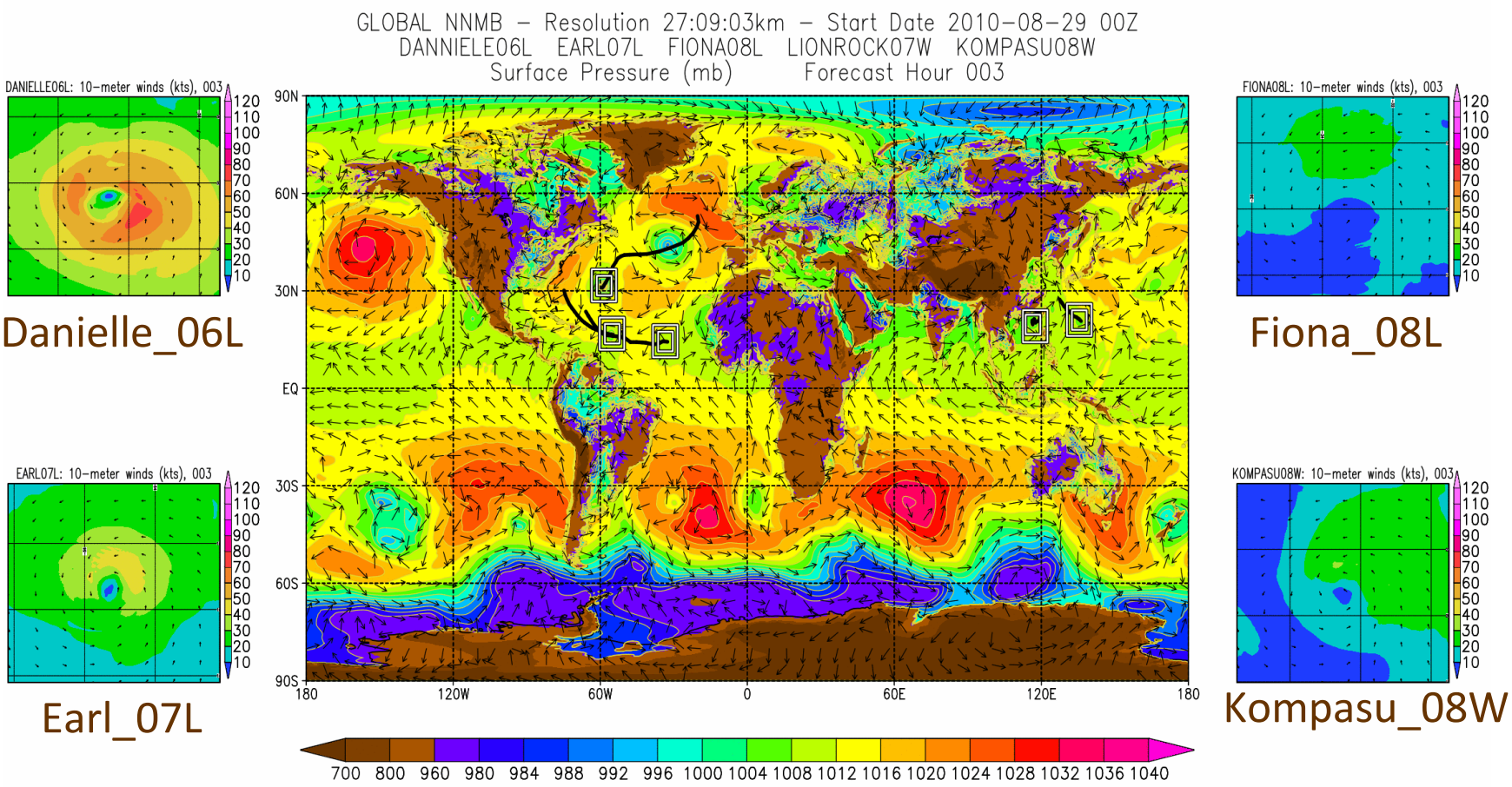




***This capacity available at HRD via HFIP.***

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

# Global Nesting

*This is perhaps the first of its kind!*
*Global Configuration with Moving Nest on Tropical Systems Worldwide!*




Danielle_06L

Fiona_08L

Earl_07L

Kompasu_08W

# Path Forward

## Summary:

- All major milestones of the Hurricane Nesting Project have been met. (i.e., 'HNMMB' has been developed within the NEMS framework)
- Proof-of-concept of global-to-local scale Hurricane Prediction System has been demonstrated and validated in a laboratory environment. (Readiness Level 5)
- Future advancements to include ocean coupling, data assimilation (DA), physics improvements, and testing and evaluation (T&E).

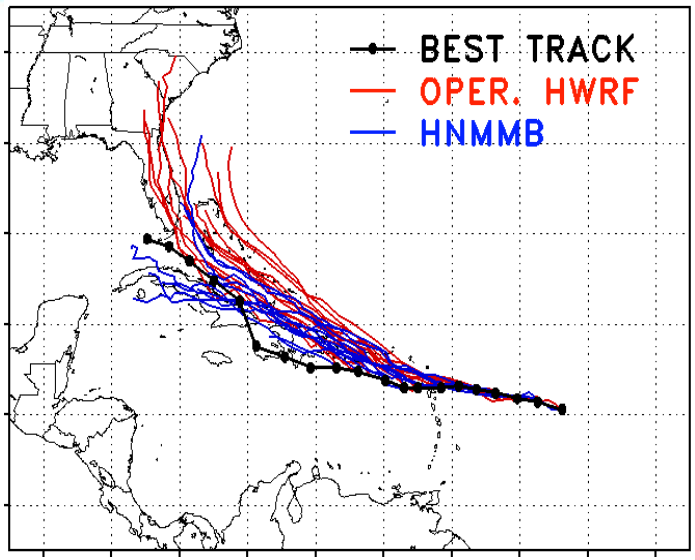
# End of Presentation

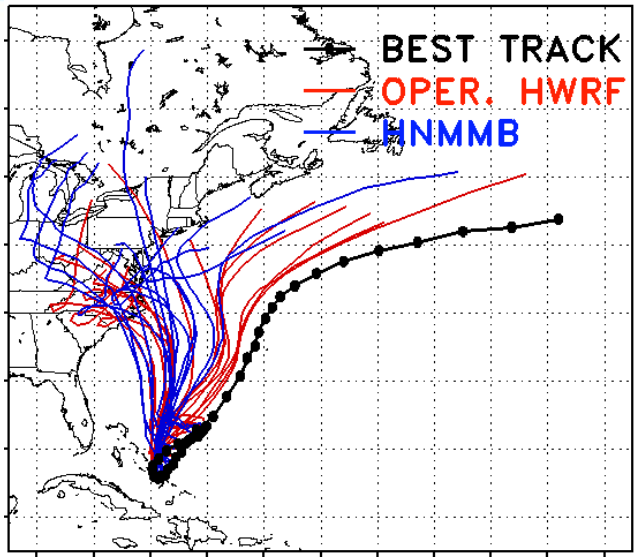

## Hurricane Nest Project

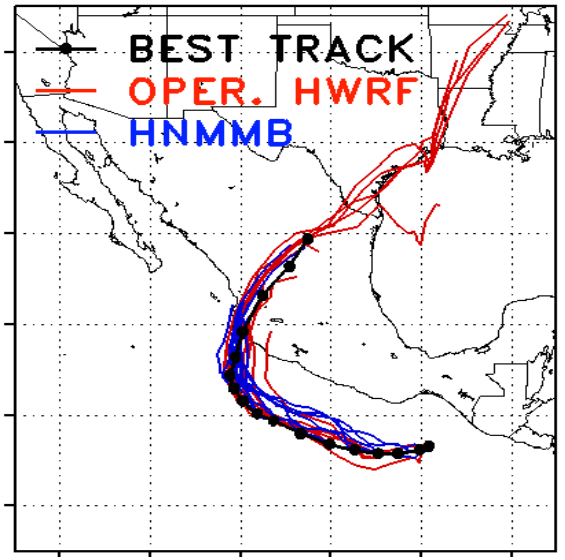
# End of Presentation

# Additional slides...

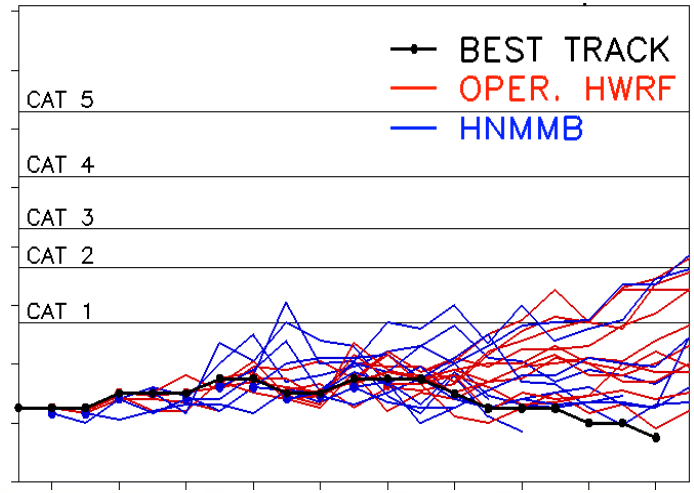
# Track & Intensity Plots

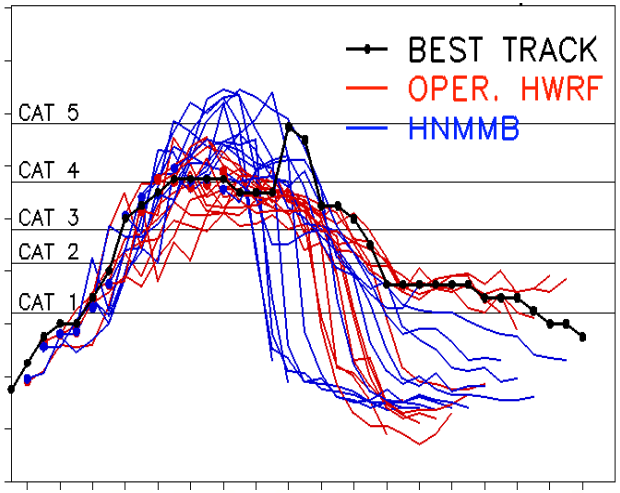


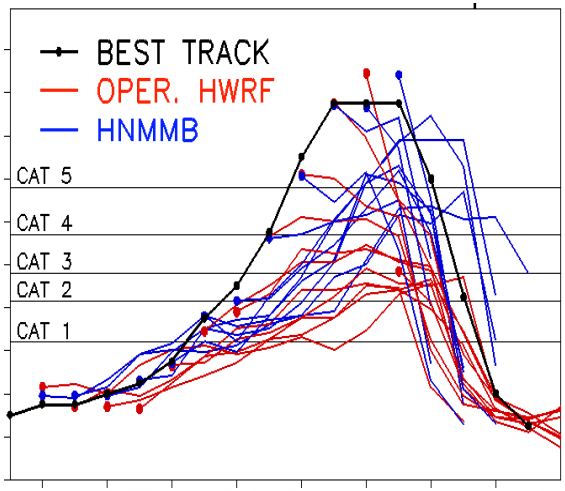




**ERIKA_05L** | **JOAQUIN_11L** | **PATRICIA_20E**



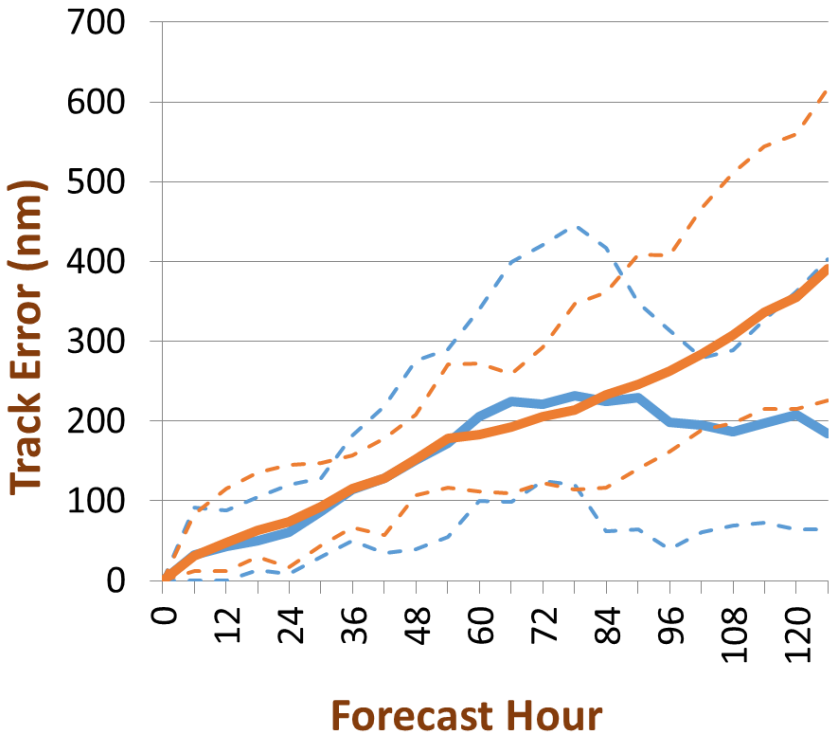



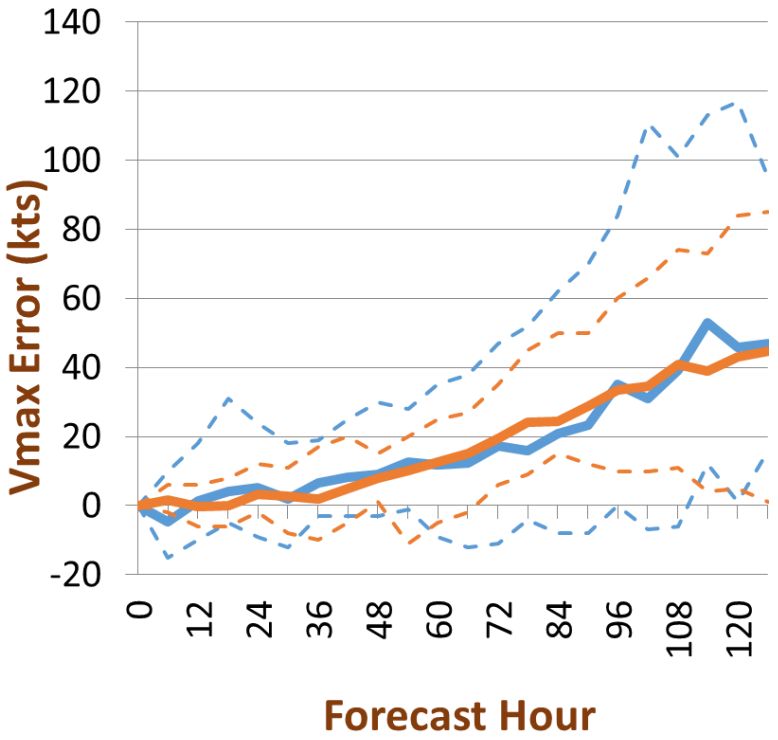



# Track & Intensity Errors: ERIKA

ERIKA (2015082518 - 2015082812)
multi-storm; "HWRF physics"

HNMMB (AVG)
HWRF (AVG)
MAX/MIN Envelope

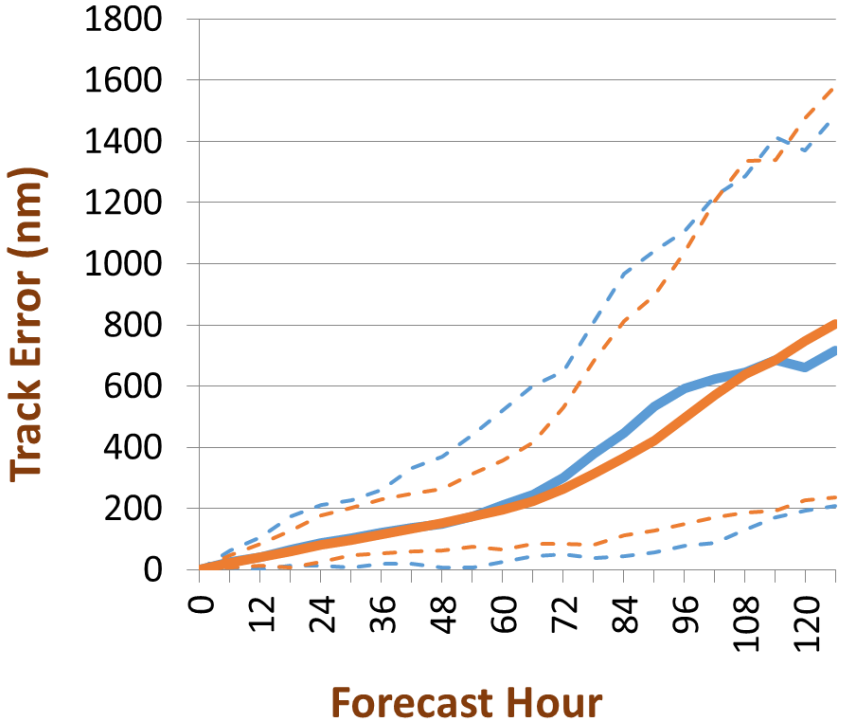


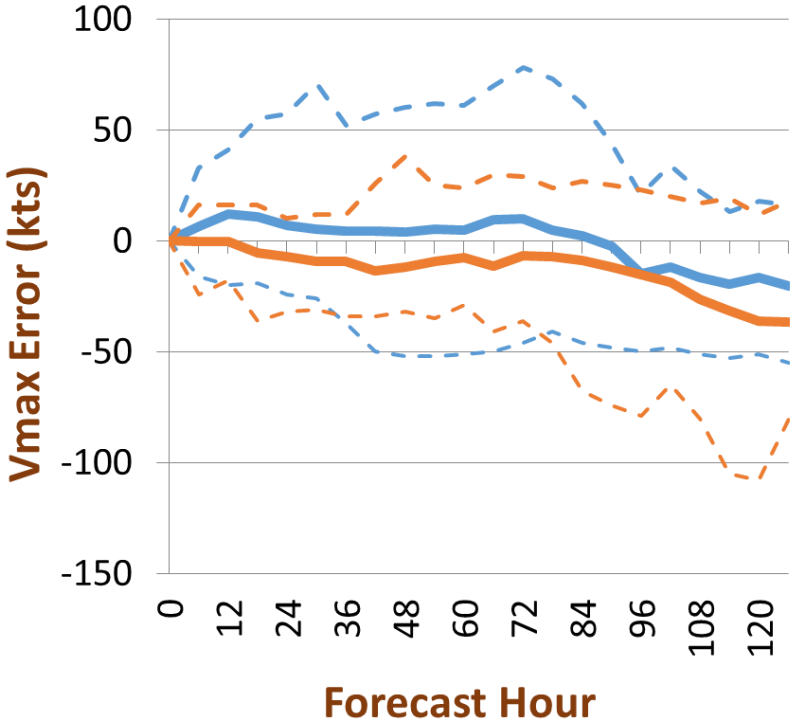



# Track & Intensity Errors: JOAQUIN

JOAQUIN (2015092800 - 2015100218)
multi-storm; "HWRF physics"

HNMMB (AVG)
HWRF (AVG)
MAX/MIN Envelope

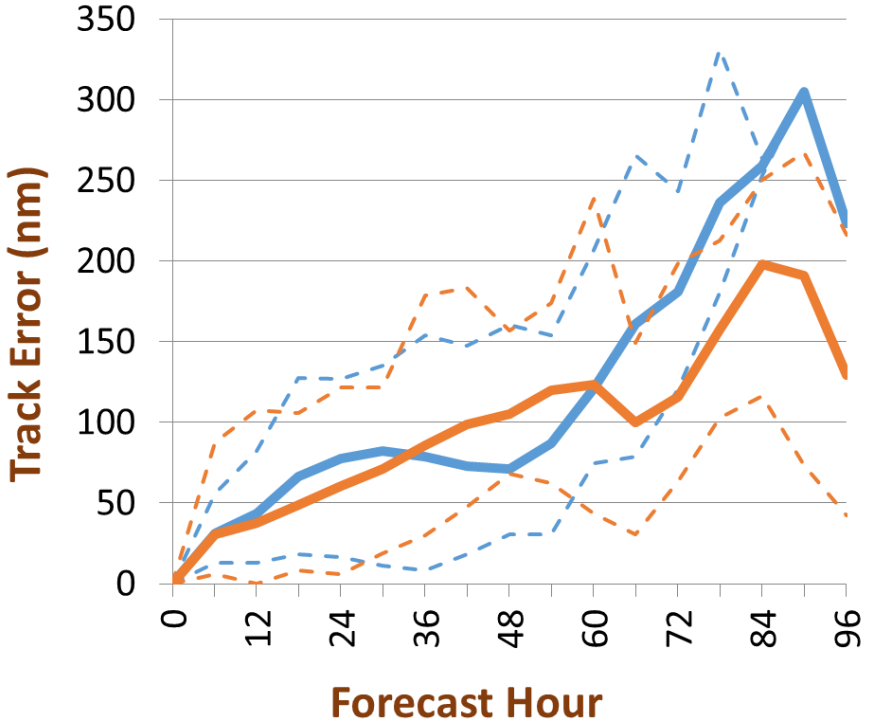


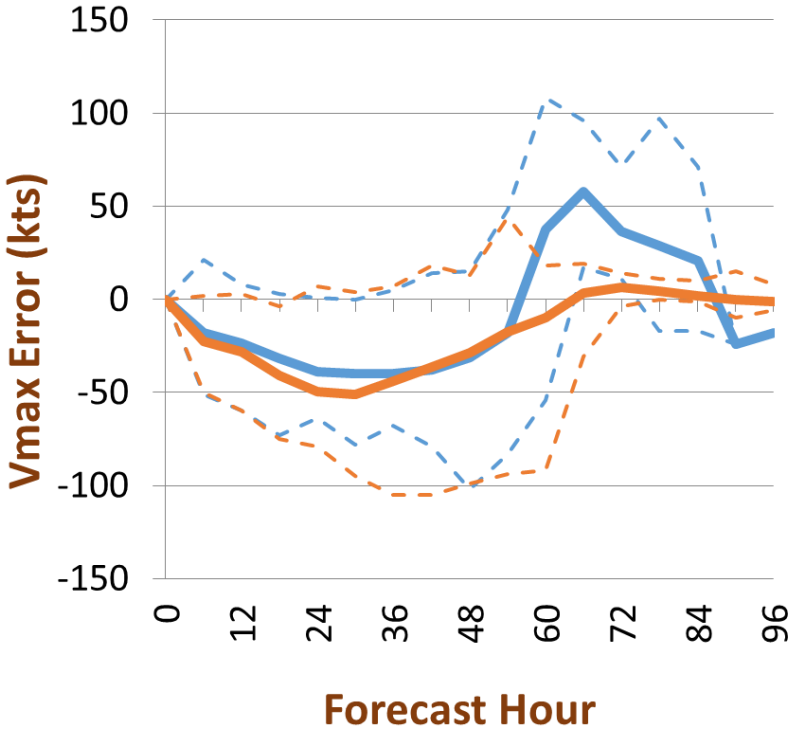



# Track & Intensity Errors: PATRICIA

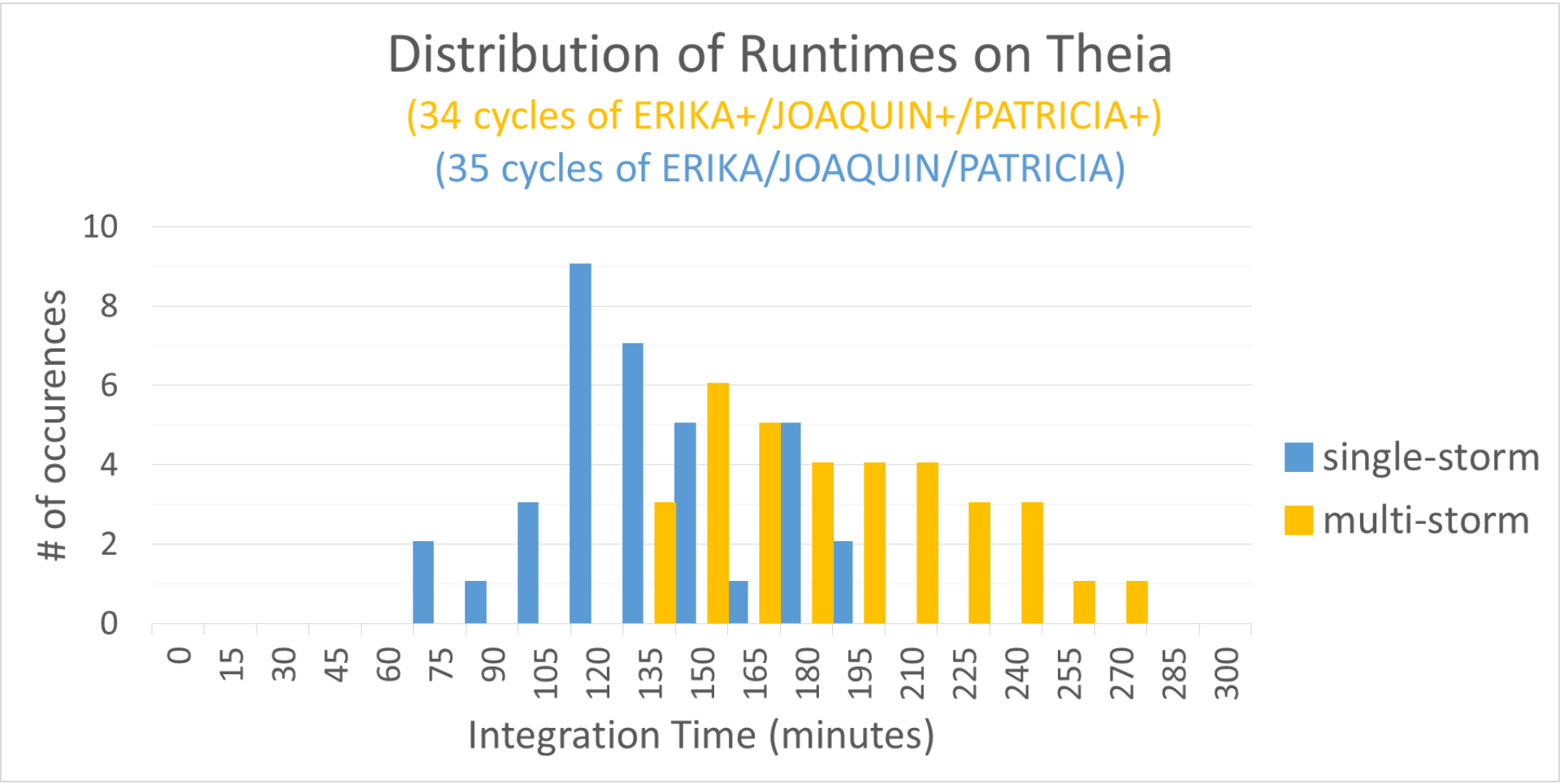
PATRICIA (2015102018 - 2015102318)
multi-storm; "HWRF physics"

HNMMB (AVG)
HWRF (AVG)
MAX/MIN Envelope

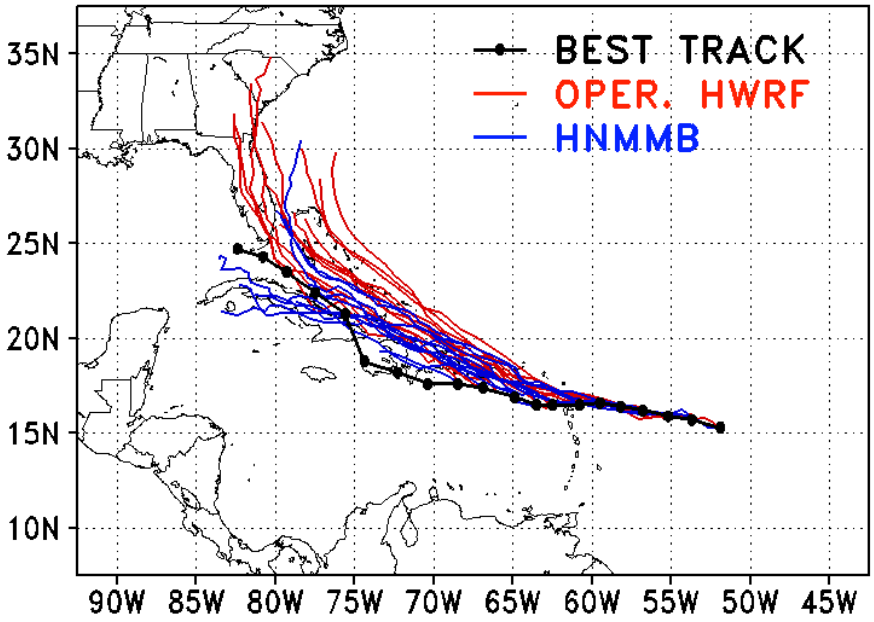


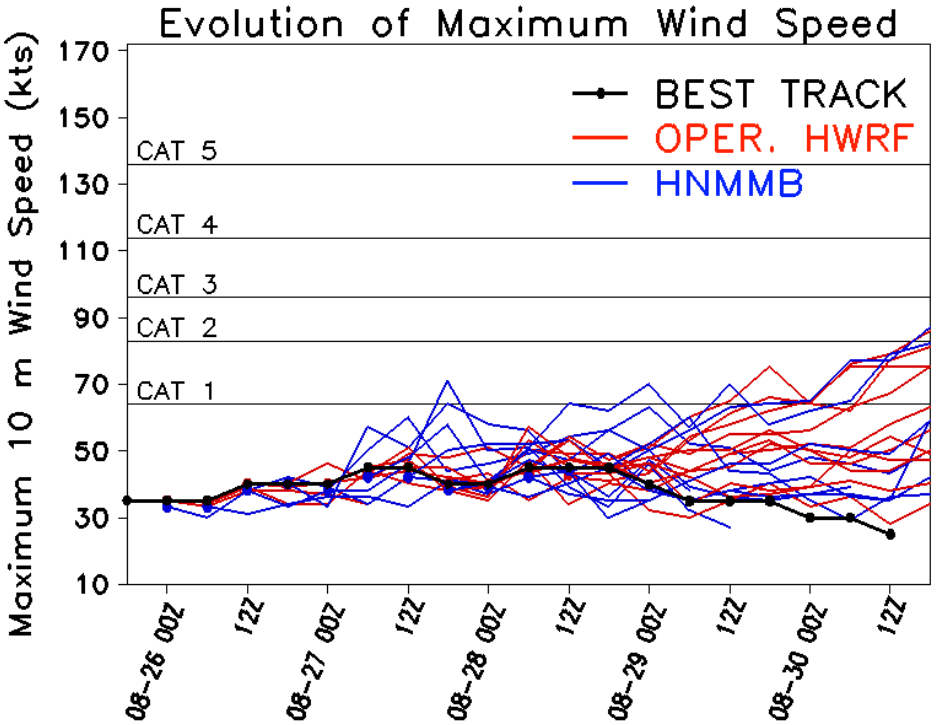



# Distribution of Runtimes

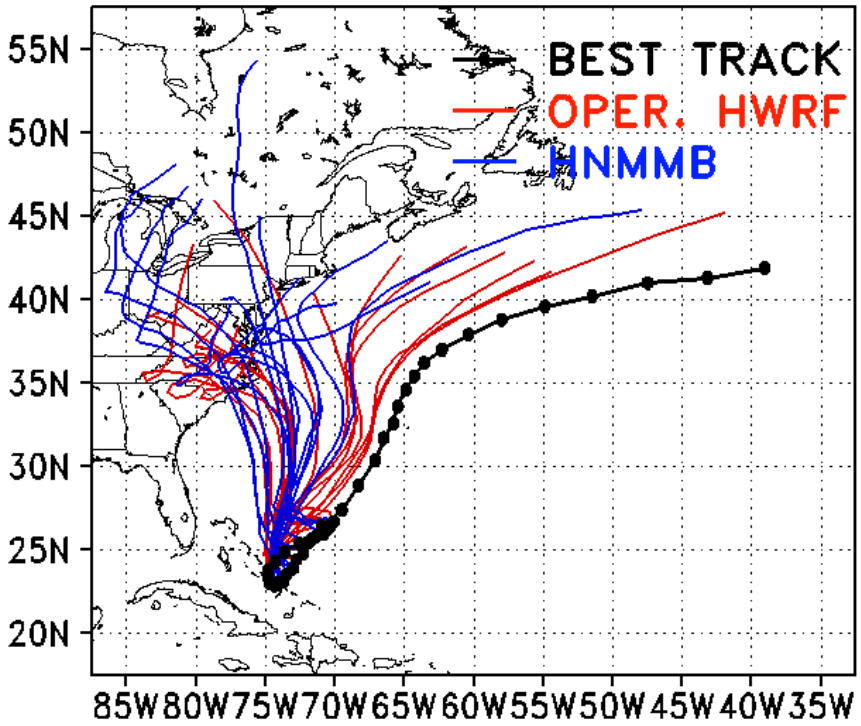


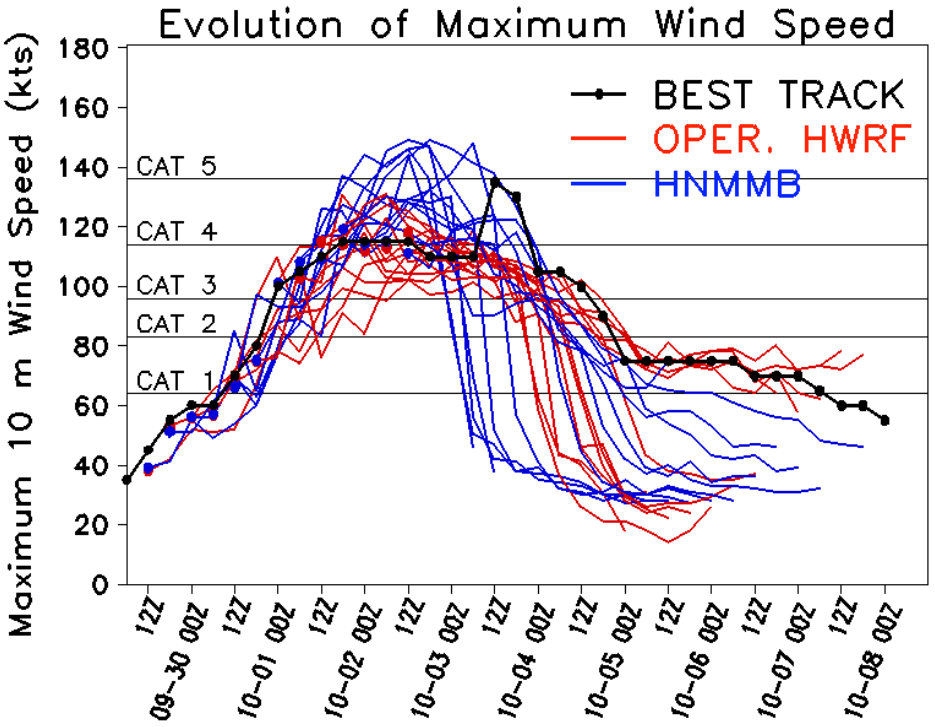
# Track & Intensity Plots: ERIKA



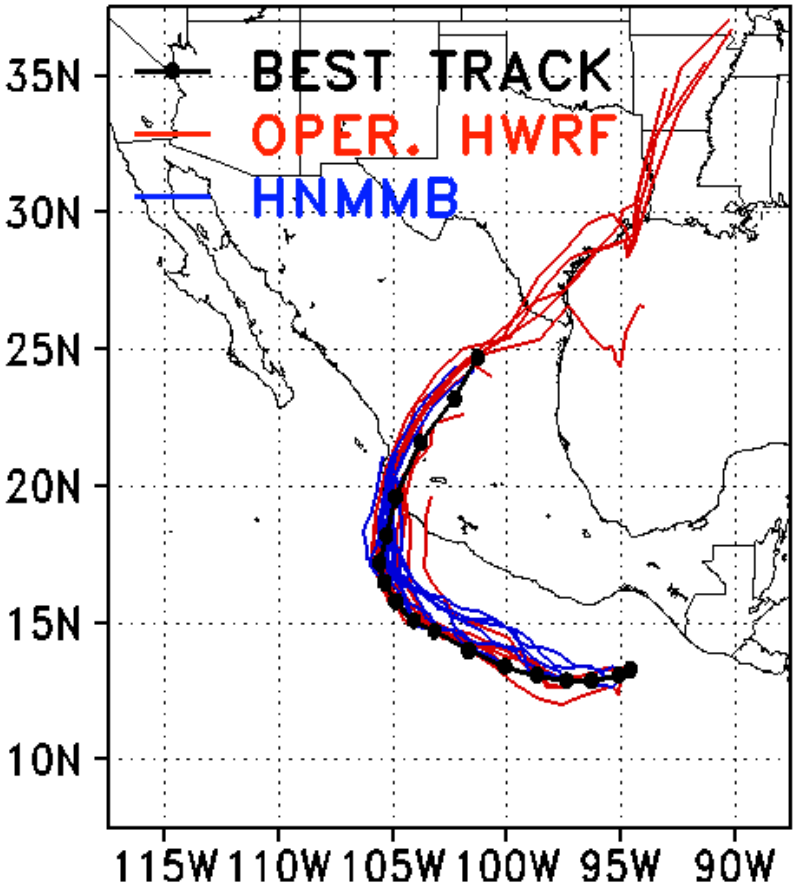



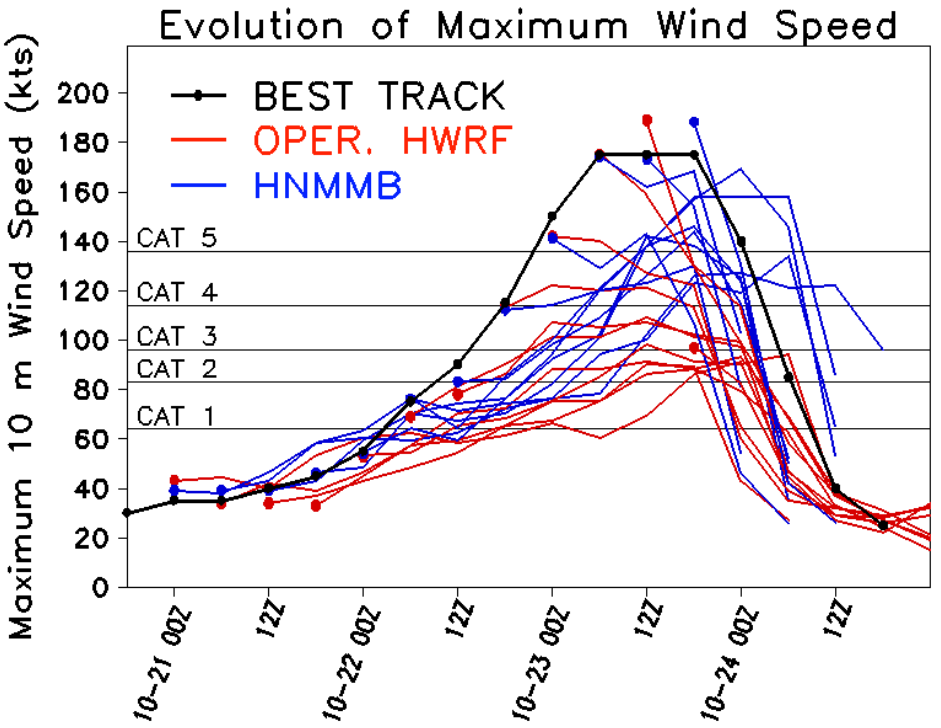
# Track & Intensity Plots: JOAQUIN



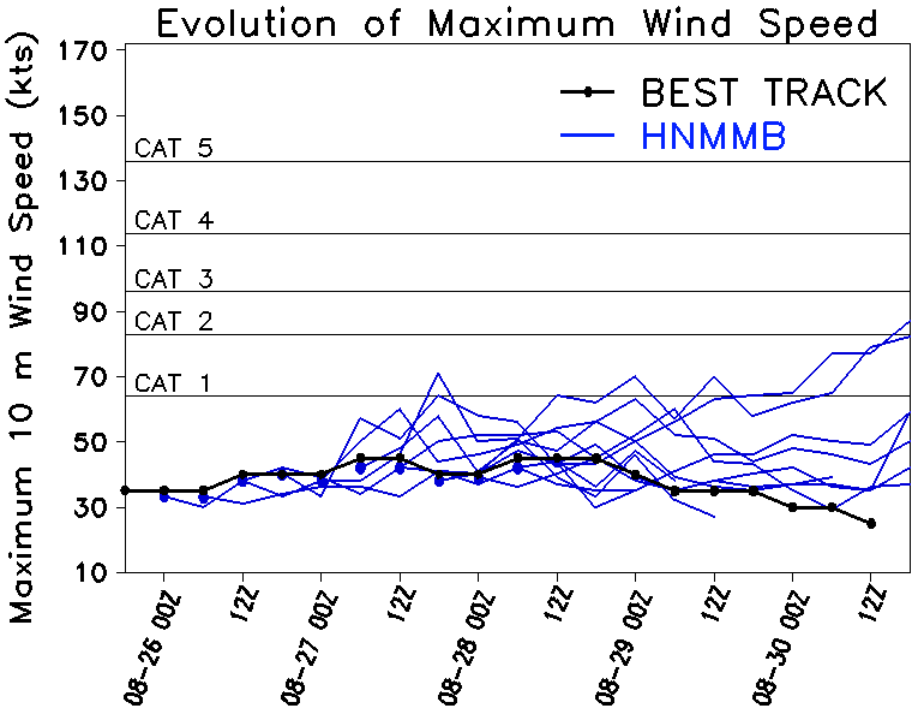



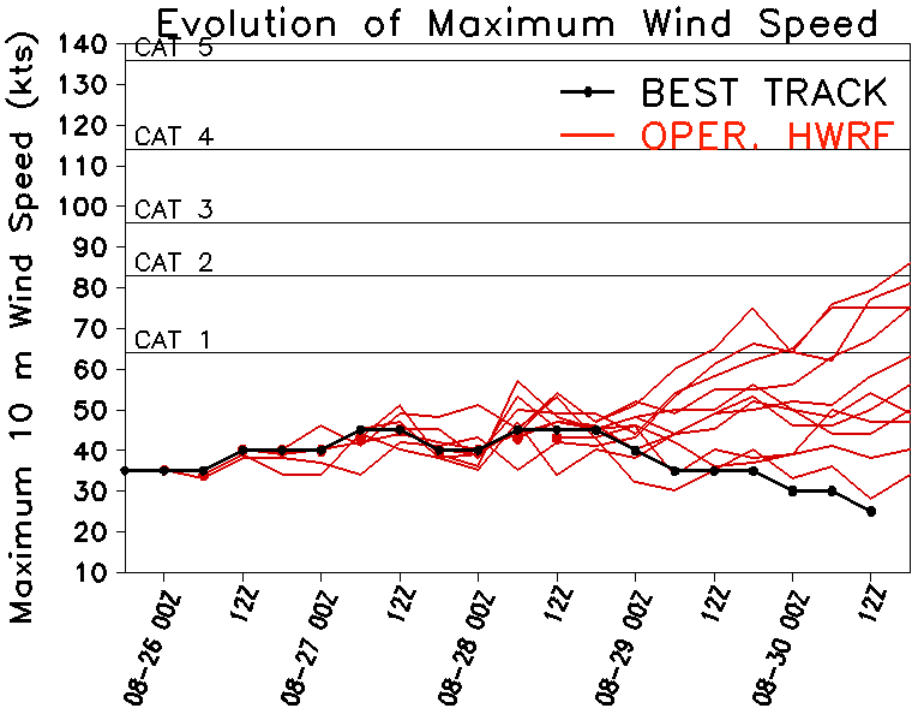
# Track & Intensity Plots: PATRICIA



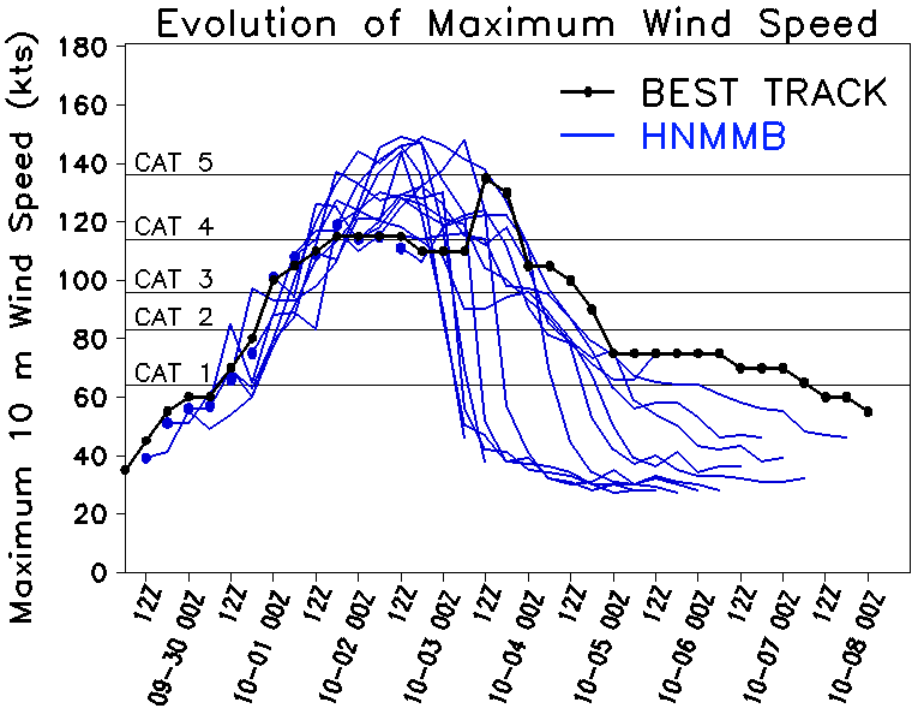



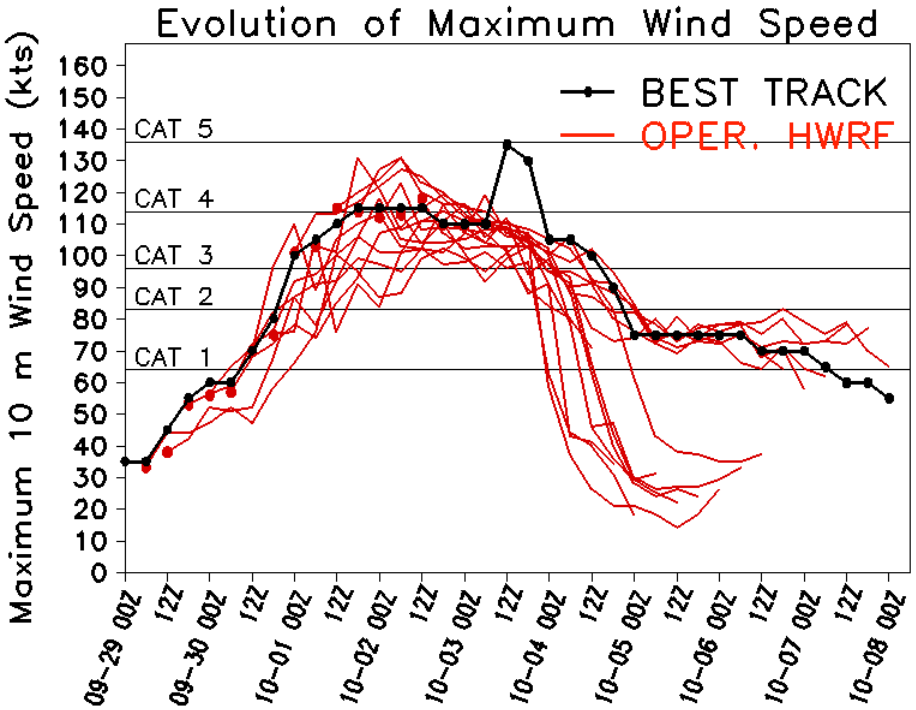
# Intensity: ERIKA



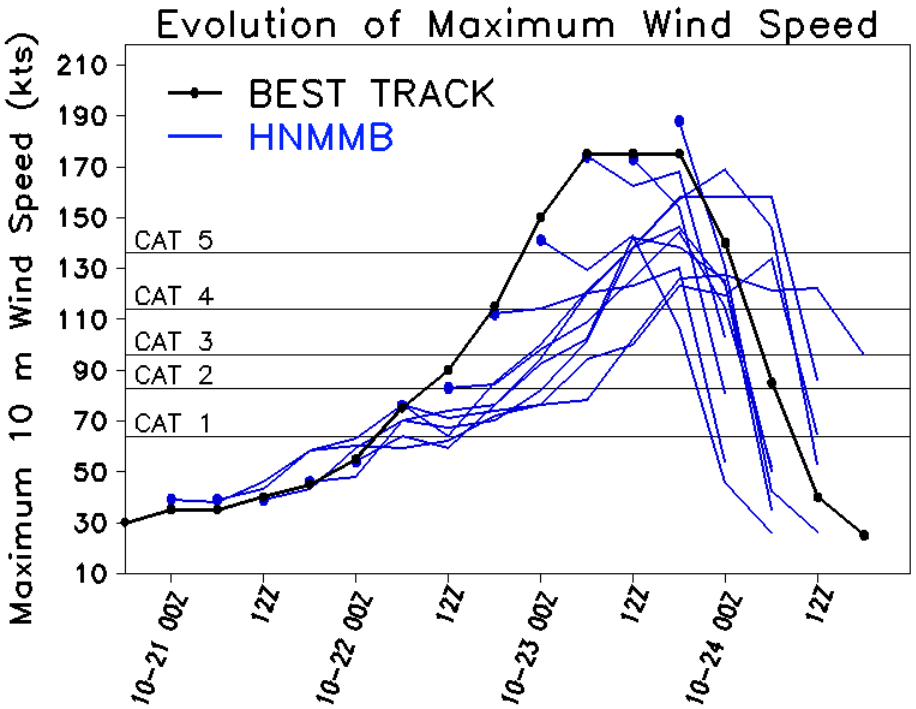



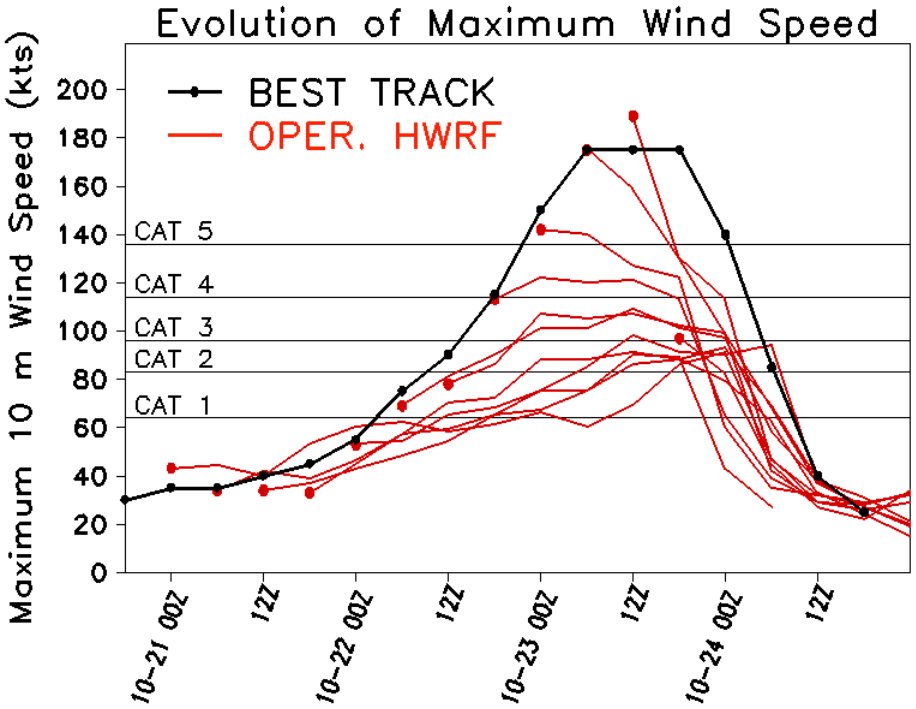
# Intensity: JOAQUIN



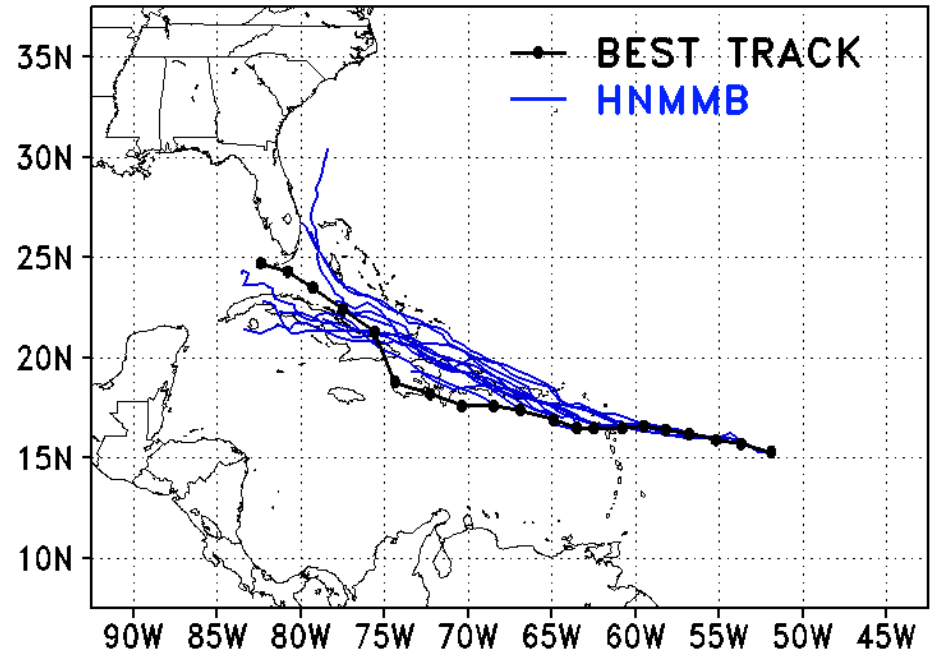



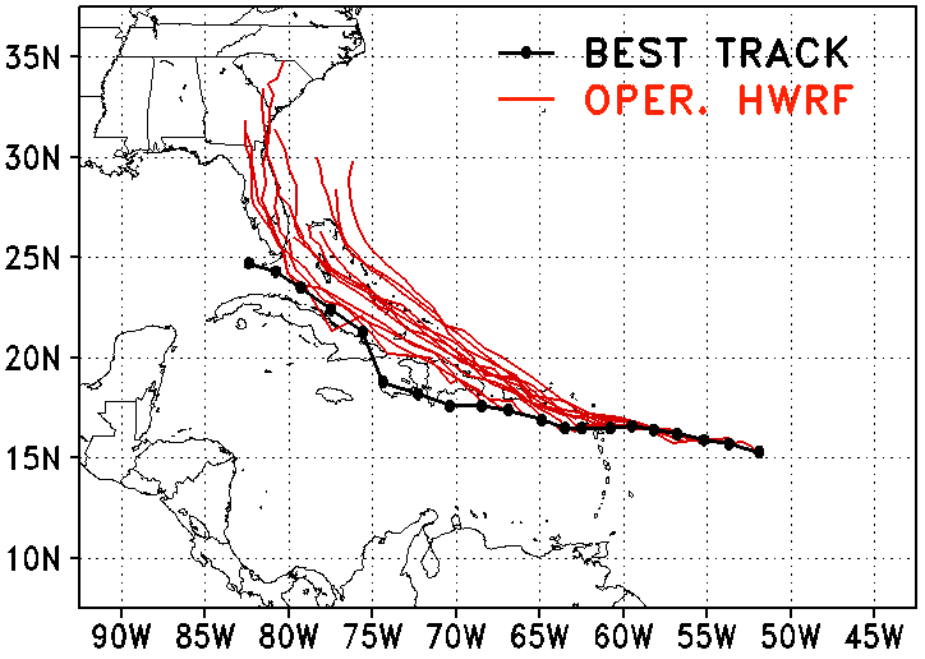
# Intensity: PATRICIA



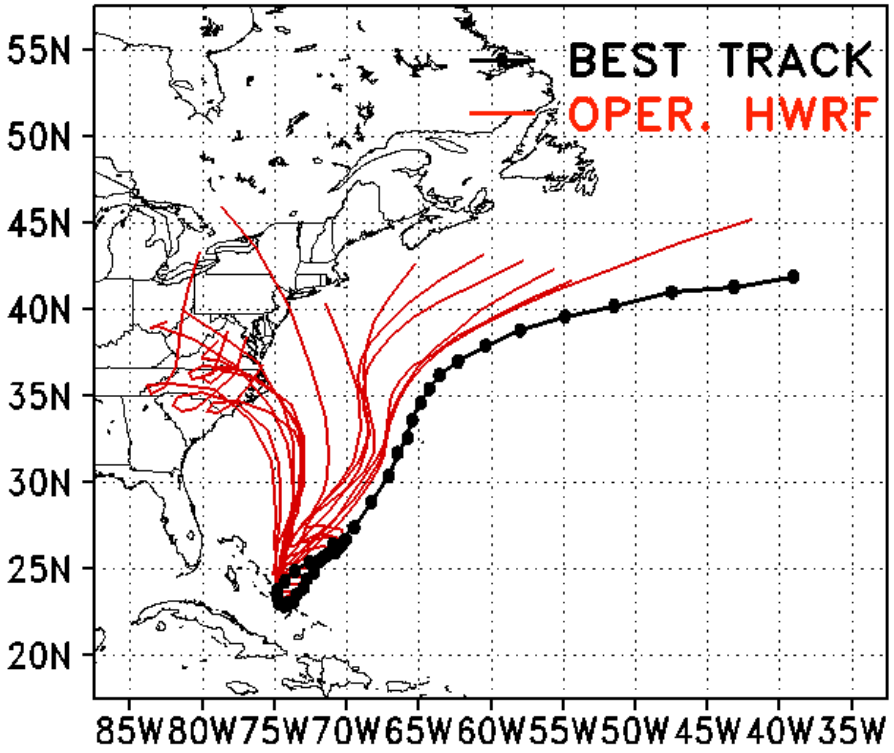



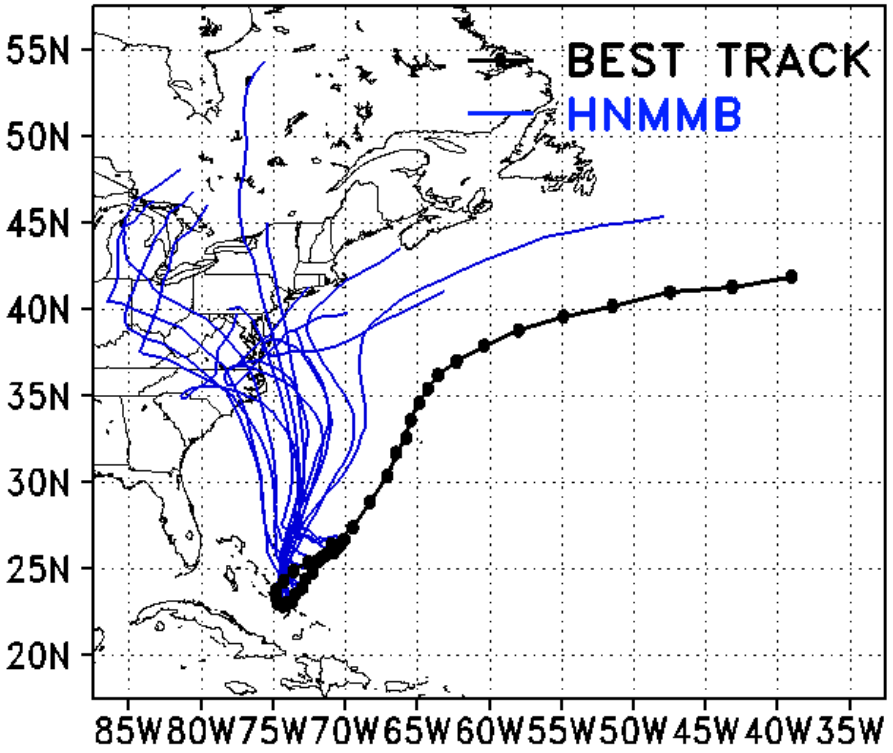
# Track: ERIKA


BEST TRACK
HNMMB
35N
30N
25N
20N
15N
10N
90W 85W 80W 75W 70W 65W 60W 55W 50W 45W


BEST TRACK
OPER. HWRF
35N
30N
25N
20N
15N
10N
90W 85W 80W 75W 70W 65W 60W 55W 50W 45W

# Track: JOAQUIN



# Track: PATRICIA